National Aeronautics and Space Administration

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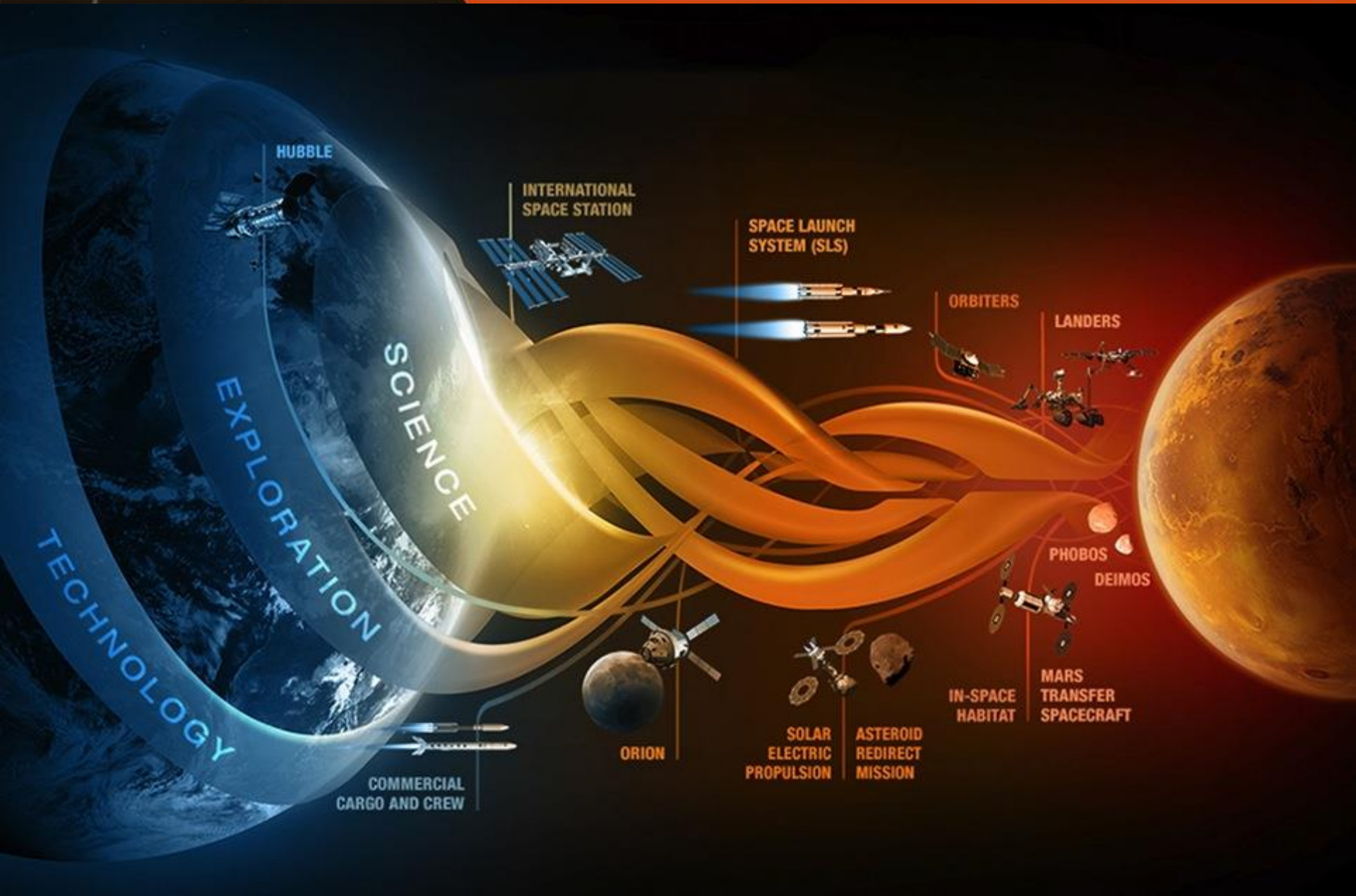
# SPACE LAUNCH SYSTEM

## SLS Technology Insertion Approach

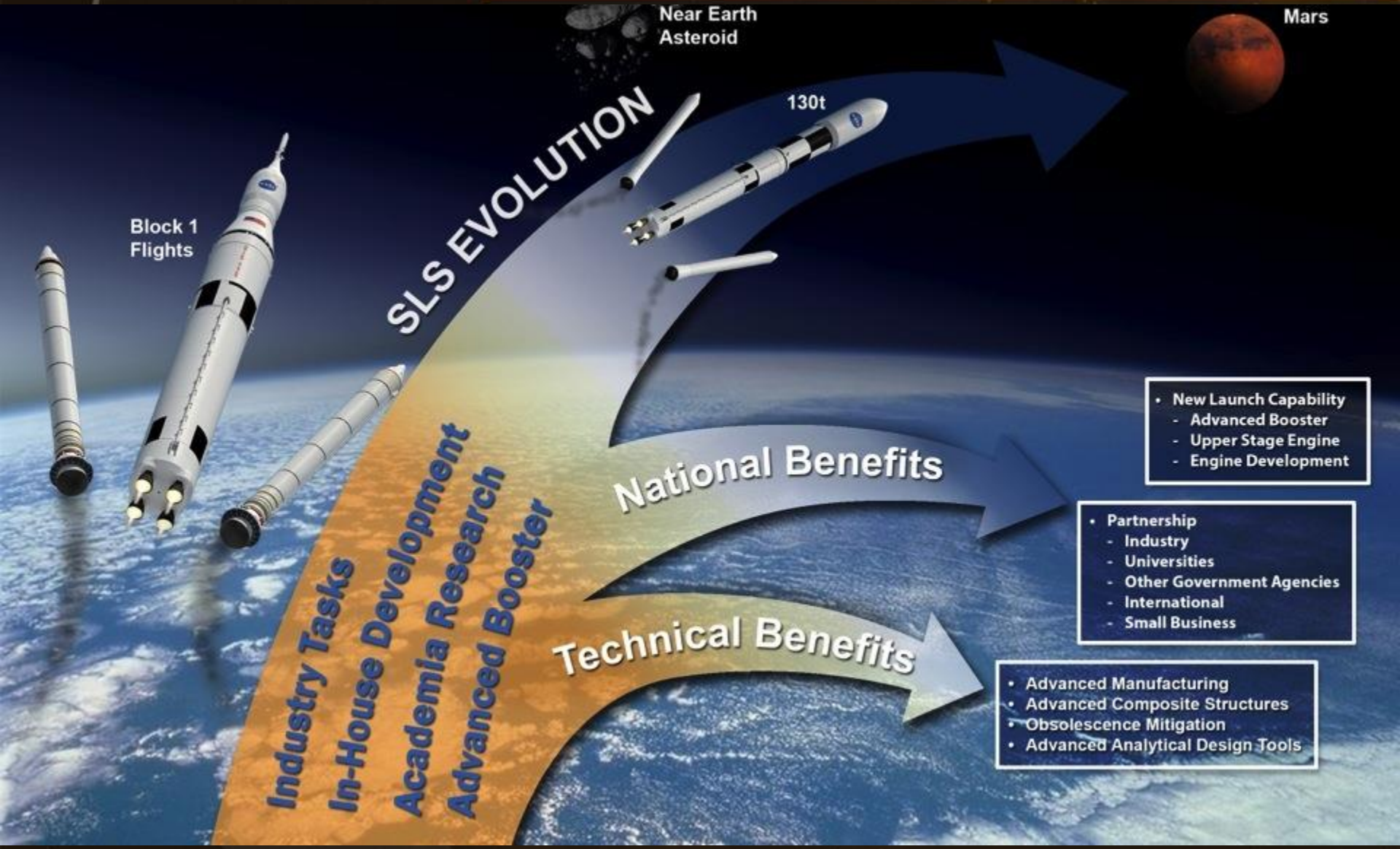
**Fred Bickley, PhD**
**Space Launch System Program**

www.nasa.gov/sls

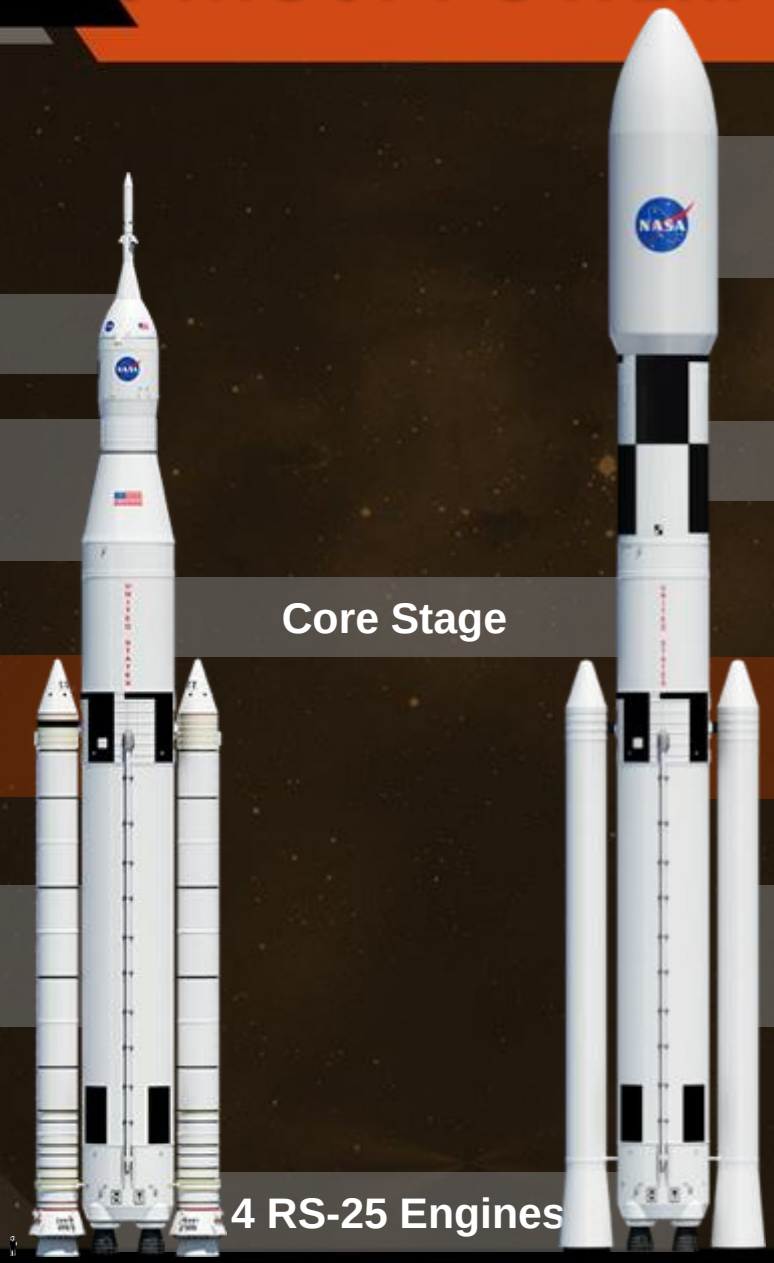
# THE JOURNEY TO MARS



# EVOLVING THE VEHICLE



# THE WORLD'S MOST POWERFUL ROCKET



Orion

Interim Cryogenic Propulsion Stage

Block I
70 metric tons

Five-Segment Solid Rocket Boosters

5, 8.4 or 10 Meter Payload Fairings

Upper Stage

Core Stage

Block II
130 metric tons

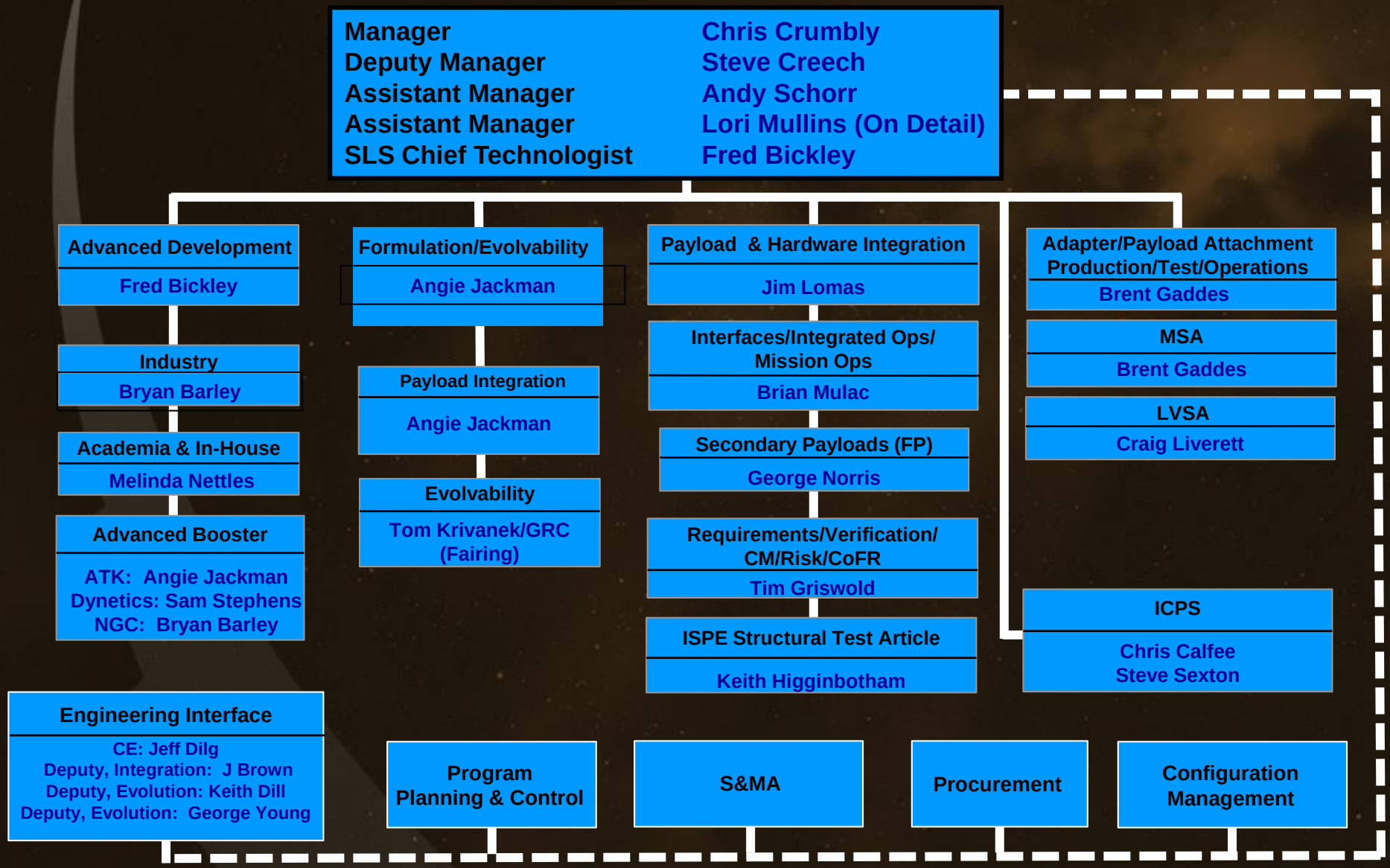
Liquid or Solid Advanced Boosters

4 RS-25 Engines

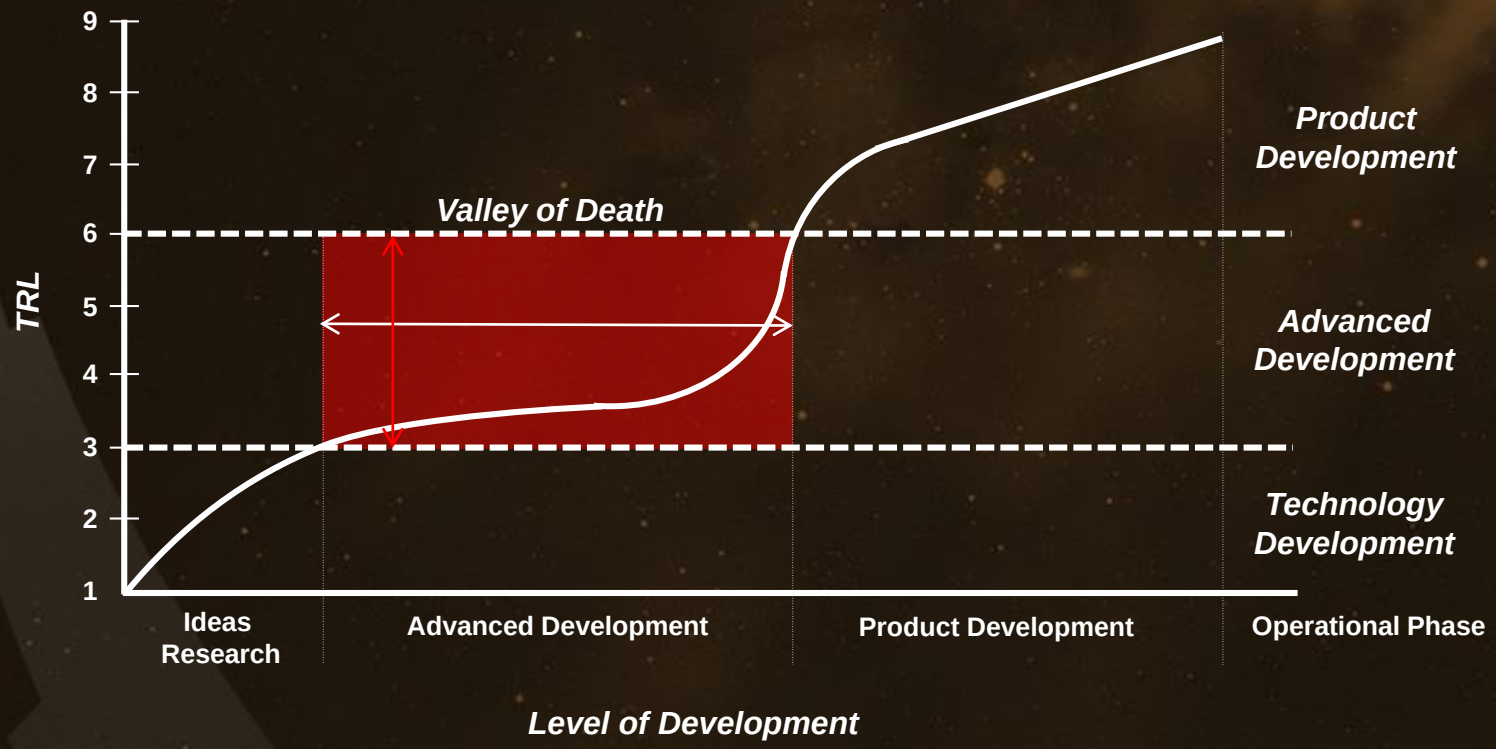
SLS SPACE LAUNCH SYSTEM

www.nasa.gov/sls

# SLS Spacecraft/Payload Integration and Evolution (SPIE)



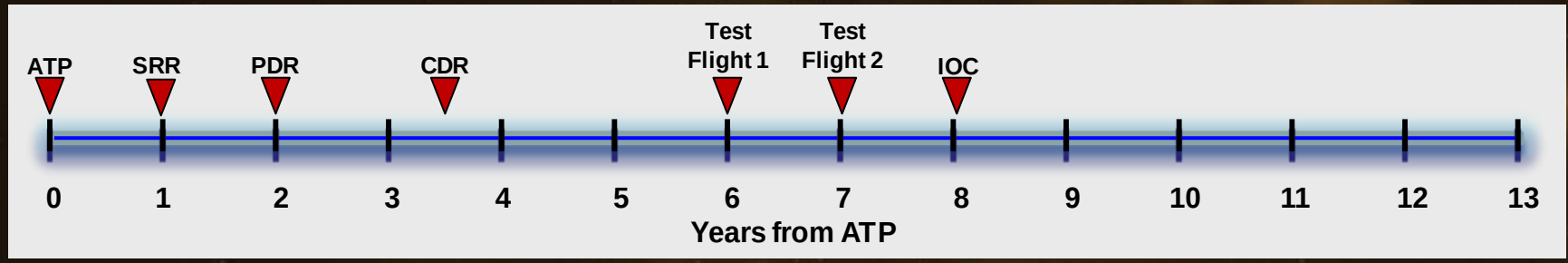
# Technology Transition



# SLS Approach to Block Upgrades

***Improvements in Performance, Safety, Reliability, Cost, and Operations***

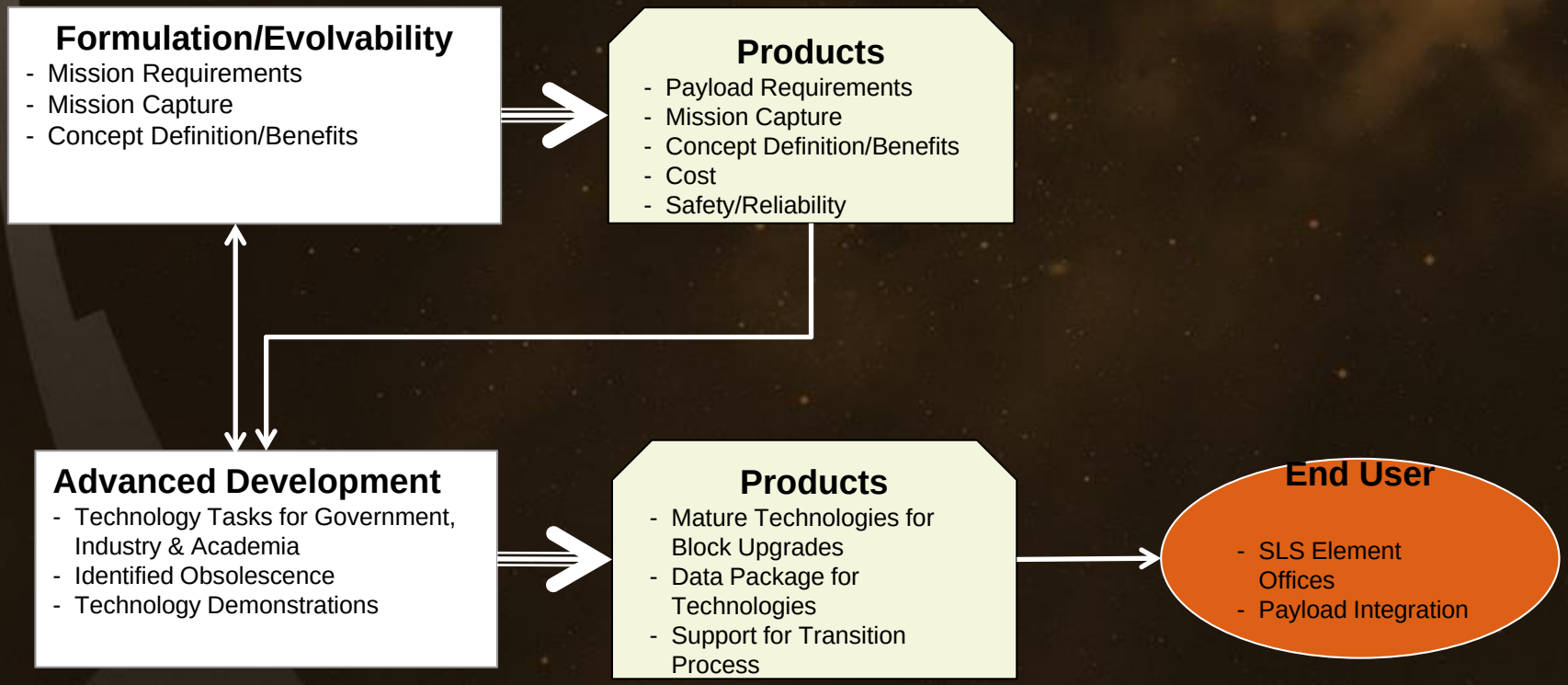
Notional Schedules




| | | | |
|---|---|---|---|
| ***Block 1B Requirements*** | ***Advanced Development*** | ***Block 1B Design/Development*** | ***Block 1B Mission*** |
| ***Block 2 Requirements*** | ***Technology Maturation**** / ***Advanced Development*** | ***Block 2 Design/Development*** | ***Block 2 Mission*** |

*** NASA, Office of Chief Technologist (TRL 1-6)**

# Technology Needs



# Current Advanced Development Tasks

## In-house Tasks:

- Cryogenic Mat'l & Process Development–Mitigate Obsolescence
- Hexavalent Chromium Free Primer for Cryo
- MPS Low Profile Diffuser
- Solide State Ultracapacitor to Replace Batteries Lattice
- Boltzmann Modeling Zero-G Propellants
- Hot fire Test LOX/H2 Additively Manu'f Injector Affordable for EUS
- Testing of Additively Manu'f Turbomachinery
- Additive Manufacturing Infrared Inspection
- Computed Tomography Sensitivity & Verification of Engine Components
- Additive Manuf. Propellant Ducts, Manifolds & Bellows
- Adv. Manuf. Of Lightweight C-C Nozzle Ext. for Upper Stage
- Performance Improvement of Friction Stir Welds by Better Surface Finish
- Composite Dry Structure Cost Improvement Approach
- Q2 Inconel 625 Mar'l Properties Development
- Q4 titanium 6–4 Mat'l Properties Development
- Pyroshock Characterization of Composite Materials (NESC funded)
- Booster Interference Loads (NESC funded
- Advanced Booster comp. Case/PBI NBR Insulation Dev (NESC funded)
- Advanced Booster Combustion Stability (NESC funded)

## Academia Tasks:

- Auburn University: High Electrical Density Device Survey for Aerospace Applications
- Louisiana State University: Improved Friction Stir Welds Using On-Line Sensing of Weld Quality
- Massachusetts Institute of Technology: Modeling Approach for Rotating Cavitation Instabilities in Rocket Engine Turbopumps
- Mississippi State University: Algorithmic Enhancement for High Resolution Hybrid RANS-LES and Large-Scale Multicore Architectures
- University of Florida: Development of Subcritical Atomization Models for Liquid Rocket Injectors and Two-Phase Flow Heat Transfer
- University of Maryland: Validation of Supersonic Film Cooling Numerical Simulations Using Detailed Measurement and Novel Diagnostics
- University of Michigan: Advanced LES and Laser Diagnostics to Model Transient Combustion-Dynamic Processes in Rocket Engines: Prediction of Flame Stabilization and Combustion Instabilities
- Flame Stabilization and Combustion Instabilities University of Utah: Acoustic Emission Based Health Monitoring of Structures
- Pennsylvania State University: Characterization of Aluminum/ Alumina/Carbon Interactions under Simulated Rocket Motor Conditions

## Awarded Industry Tasks:

- Aerojet: AUSEP Engine Study
- Exquadrum, Inc: AUSEP/DESLA Concept Development
- Moog: AUSE High Press LOX Flow Control Valve Manufacturing Study
- Northrup Grumman: System Requirements and Affordability Assessment for an AUSE
- Pratt & Whitney Rocketdyne: Requirements, Logistics, and System Assessment of an AUSE
- ULA: Integrated Vehicle Fluids (IVF) Testing

## Advanced Booster Engineering Demonstration and Risk Reduction Tasks (ABEDRR):

- Dynetics & Aerojet: Modernization of the F-1B Engines, Combustion Stability, and Cryotank Manufacturing
- ATK: Demonstration of a FWC for High-Energy Propellant SRB
- Northrop Grumman: Demonstration of a Common Bulkhead LOX/RP Composite Cryogenic Tank

*Details of individual tasks can be found at [www.ntrs.nasa.gov](http://www.ntrs.nasa.gov) (search for NASA/TM-2015-218201) in the SLS SPIE Advanced Development FY14 Annual Report.*

# SLS Advanced Development Group Technology Focus Areas

- SLS Industry Task Focus Areas
  - Exploration Upper Stage (EUS)
    - Light weight structures and materials, including composites
    - Advanced LOX/LH2 engine
    - Cryogenic storage for long duration missions
    - Advanced/Additive Manufacturing (Selective Laser Melting)
  - Universal Stage Adapter
    - Light weight structures and materials, including composites
    - Design

- SLS In-House and Academic Task Focus Areas
  - Propulsion
  - Stages, including upper stages
  - Advanced boosters
  - Shrouds
  - Operations
  - Payload accommodations
  - Analytical modeling
  - Advanced manufacturing
  - Materials development